(12) UK Patent Application (19) GB (11) 2 110 658 A

(21) Application No **8133112**
(22) Date of filing **3 Nov 1981**
(43) Application published **22 Jun 1983**
(51) INT CL[3] **C02F 3/30**
(52) Domestic classification **C1C 311 431 432 436 43Y 442 L**
(56) Documents cited **GB A 0229214**
(58) Field of search **C1C**

(71) Applicant
Agrotechnika narodny podnik podnikove riaditelstvo, (Czechoslovakia), Zvolen, Czechoslovakia
(72) Inventors
Svatopluk Mackrle, Vladimir Mackrle, Oldrich Dracka
(74) Agent and/or address for service
Lloyd Wise Tregear and Co., Norman House, 105—109 Strand, London, WC2R 0AE

(54) Apparatus for cleaning waste liquid

(57) The water cleaning is carried out by means of anaerobic denitrification, aerobic activation and nitrification by means of a uniform activated sludge. The apparatus has a denitrification space (6) in one vessel connected to a crude water intake (8). In the same vessel a separation space (3) for fluid filtration is connected with an outlet (31) and is separated from the denitrification space (6) by means of an inclined partition wall (2), preferably of a conical shape. The separation space (3) is connected with the denitrification space (6) by means of a sludge outlet (13). The denitrification space (6) is connected to an activation space (5) in another vessel which is provided with aerating elements (28).

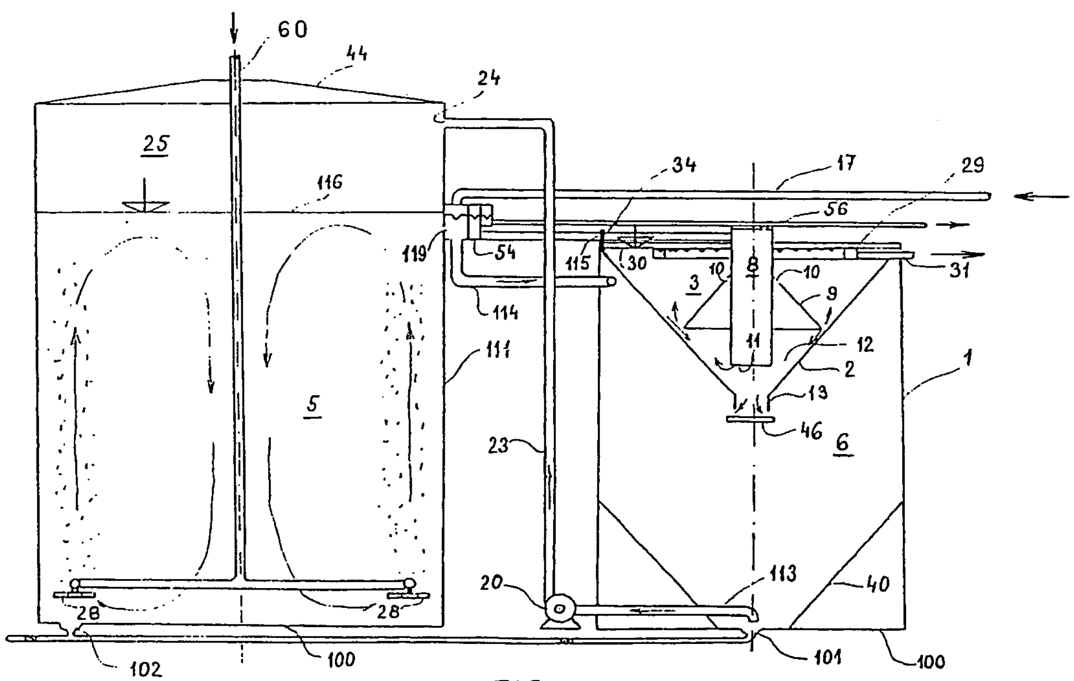

FIG. 1

The drawings originally filed were informal and the print here reproduced is taken from a later filed formal copy.

GB 2 110 658 A

BEST AVAILABLE COPY

2110658

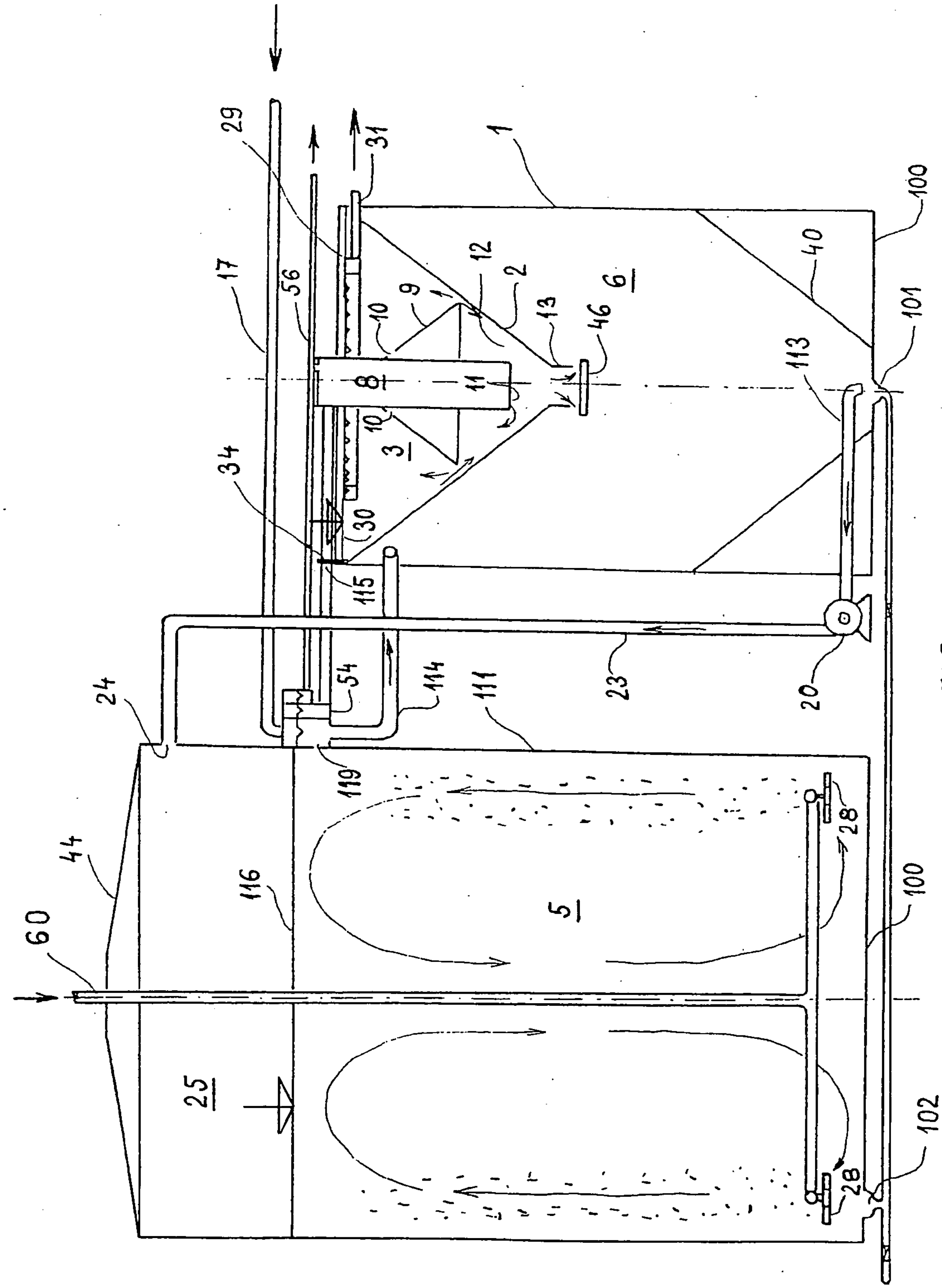

FIG. 1

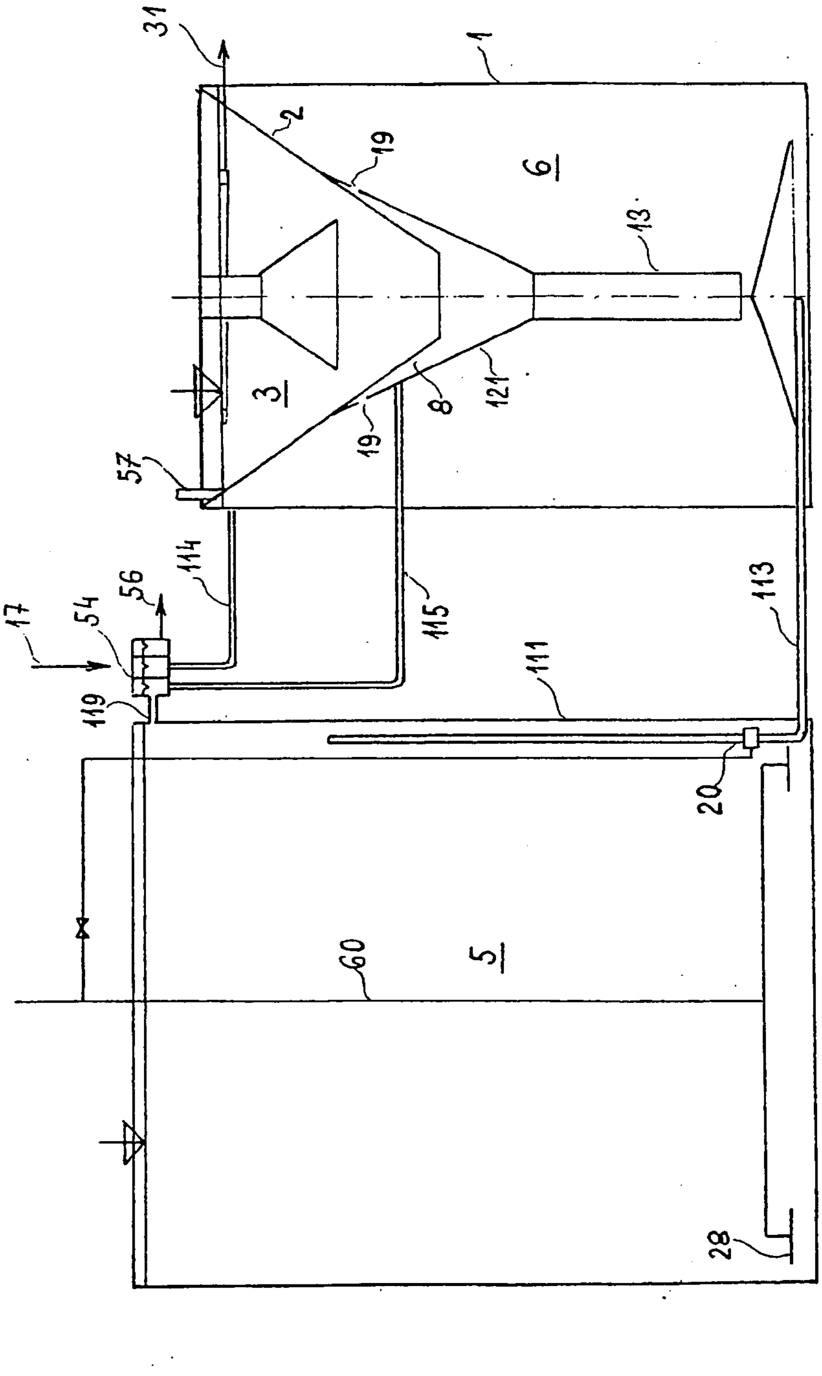

FIG. 2

2110658

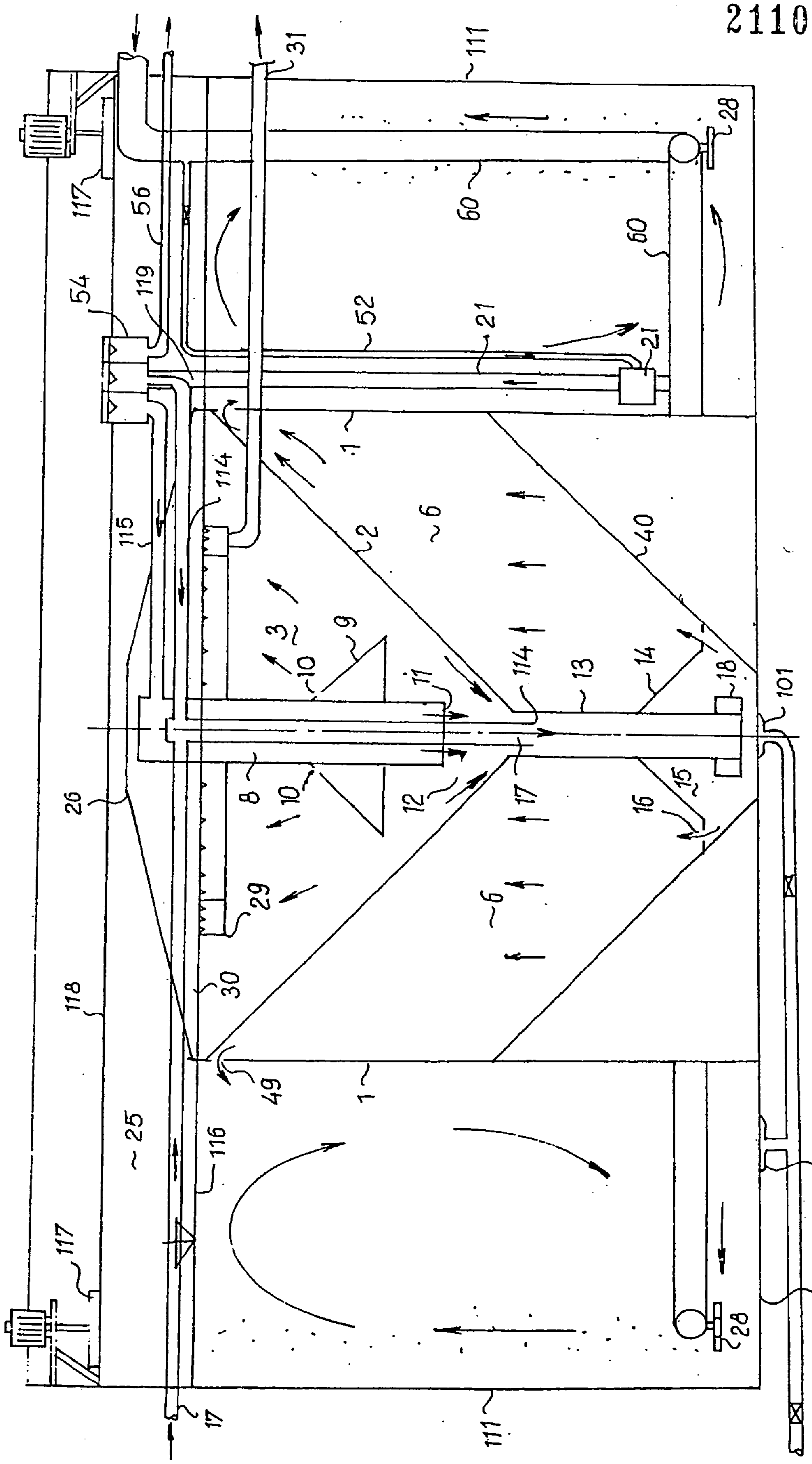

FIG. 3

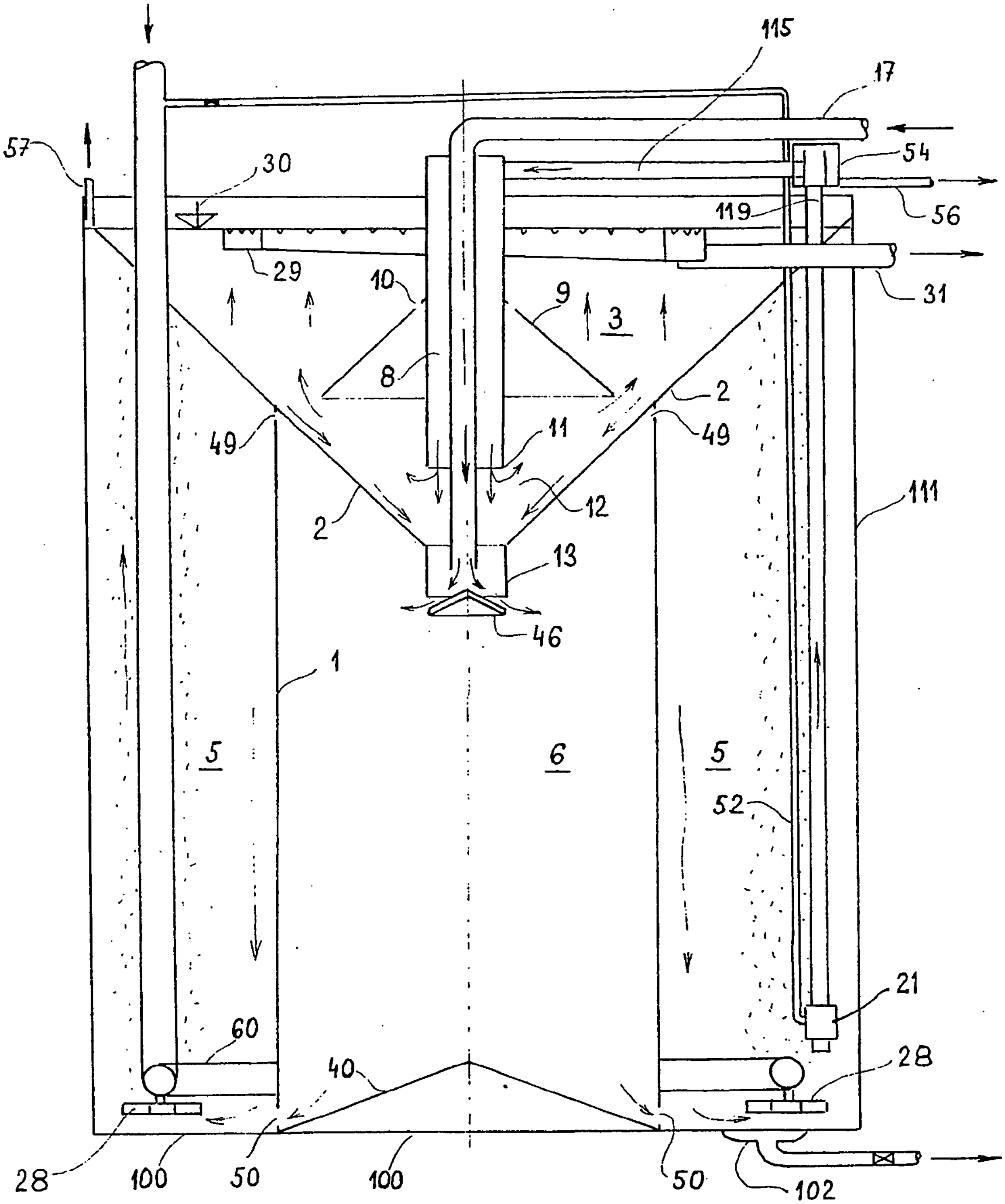
115
17
54
57
30
56
119
29
10
9
3
31
8
2
49
11
49
12
111
2
13
46
1
5
6
5
52
21
60
28
40
28
100
50
100
50
102

FIG. 4

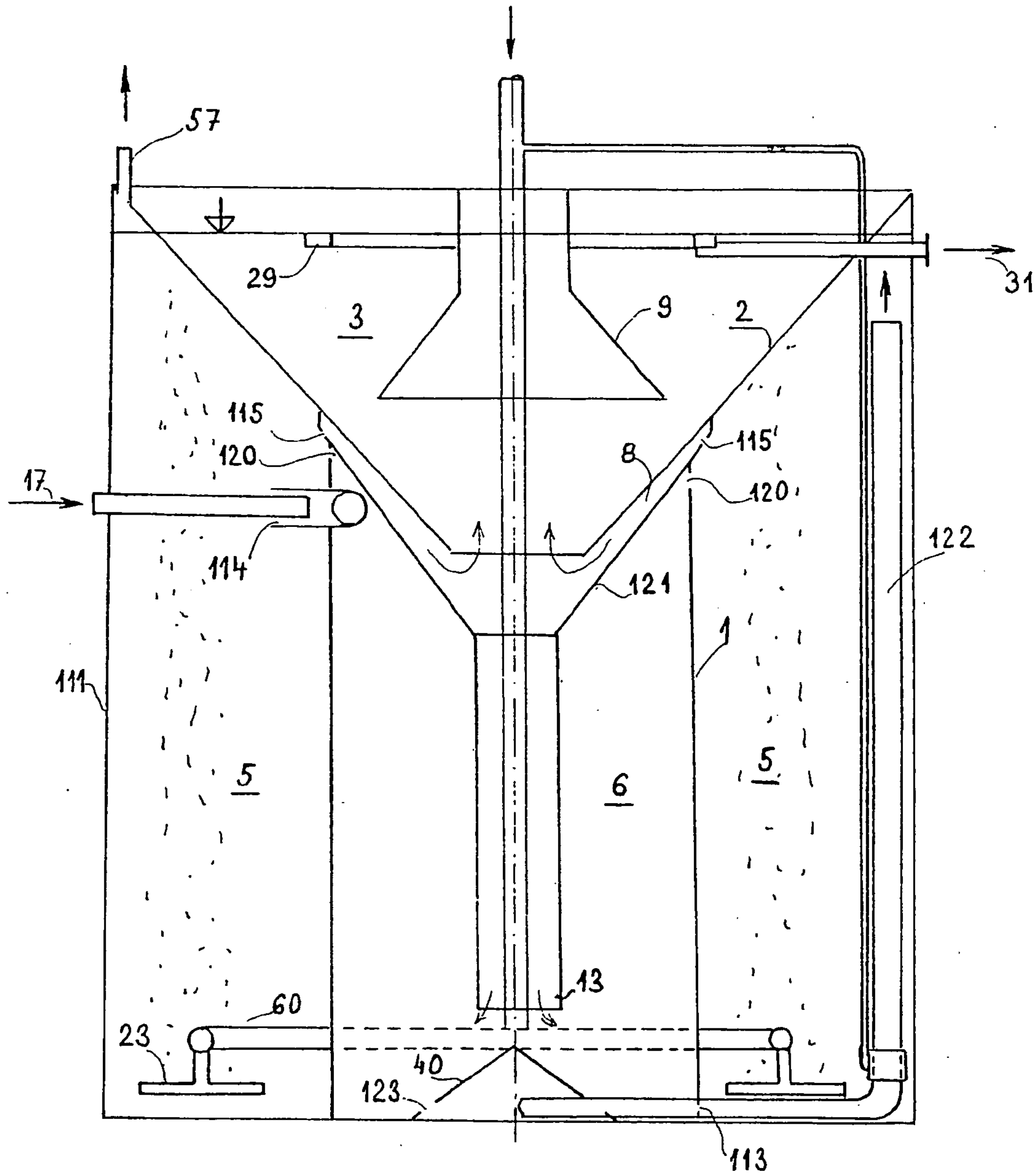
57
29
3
9
2
31
115
120
115'
8
120
17
114
121
122
111
1
5
6
5
13
60
23
40
123
113

FIG. 5

SPECIFICATION
Apparatus for cleaning of waste liquid

The present invention relates to an apparatus for biological cleaning of waste water containing carbonates and nitrates by means of anaerobic denitrification, aerobic activation and nitrification.

Such apparatus is particularly suited for complex purification of waste water discharged into standing waters, or for the treatment of waste water with a high ammonia content with inherent organic nitrogen, for example slurry from farm animals.

Methods of removing nitrates from waste water along with removing carbonate matter are known and used in water purification. Best known method is by submitting unified activated sludge to alternate aerobic and anaerobic conditions.

Such complex method of water cleaning comprise enzymatic oxidation processing of organic matter in the aerobic activation process with the oxidation of ammonia onto nitrates, whereas the anaerobic part of the process consists of the reduction of nitrates under the presence of organic carbonates acting as hydrogen donators for gaseous nitrogen. Conditions for an effective course of the nitrification and denitrification process are known in which the most important are the maintenance of the temperature range within 13 and 35°C, suitable pH, and particularly sufficient age of the sludge, ensuring the necessary concentration of nitrification and de-nitrification micro-organisms in the activated sludge.

Until now, the cleaning of waste water along with the removal of nitrates has been most frequently carried out in well known apparatus where the processes of aerobic activation as well as that of anaerobic denitrification take place in independent vessels, and the separation of activated sludge is achieved by sedimentation in an independent sedimentation vessel from which the separated activated sludge is pumped back into the first state during the purification process.

Various combinations of interconnecting the cleaning vessels are known, possibly also with the addition of secondary nutrients. The most suitable apparatus has two interconnected cleaning tanks the first one serving for the denitrification and the other for the activation, while the crude or unpurified water is fed into the denitrification tank; from the activation tank the water recirculates into the denitrification tank, whilst the activated sludge separated by sedimentation, is pumped into the denitrification tank. The described combination was used due to its simplicity and also due to the fact that it does not require the addition of secondary nutrients.

Further reactors have been designed for the mentioned purification making use of the separation of activated sludge by fluid filtration with automatic returning of the activated sludge into the process. Such equipment also used anaerobic denitrification with the intake of crude water and aerobic activation with the recirculation of cleaned water from the activation tank into the denitrification tank. The water from which the activated sludge has been separated being delivered from the aerobic activation tank, into a separation chamber, the separation chamber is arranged above the aerobic activation tank. The separated activated sludge is then returned into the aerobic activation tank, and then is passed to the denitrification tank by recirculation.

These known reactors, however, have various disadvantages. They require mixing means in the denitrification tank or space in order to maintain the activated sludge in suspension. The specific output of known types of equipment is rather low and their dependence on climatic conditions is considerable. Owing to the relatively low effectivity of separation by sedimentation no high concentration of activated sludge can be achieved in these reactors. The process of nitrification/denitrification depends on the age of the sludge to a high extent, excessive specific capacities of reactors have to be used, which results in a poor specific output. On the one hand, the large volumes of such reactors lead to the high cost of such equipment, also they result in a considerable heat exchange with the surroundings, which is exceedingly unfavourable due to the temperature dependence of the nitrification/denitrification process, in particular during the winter.

Reactors with the separation of activated sludge by fluid filtration are characterized by rather high concentrations of activated sludge, but the concentration in the denitrification tank is lower than in the aerobic activation tank, since the activated sludge, as has been mentioned, passes into the denitrification tank by recirculation from the aerobic activation tank. Further drawbacks of such equipment are problems of scum removal that tends to be produced during the process of aerobic activation, particularly when concentrated waste water should be cleaned, due to the free surface of the aerobic activation tank being considerably reduced by the separation chamber located above the activation tank.

It is an object of the present invention to create an apparatus that eliminates or reduces the disadvantages of known types of design, while allowing a substantial intensification of the purification process and an effective destruction of scum that is generated in the aerobic activation space, whilst ensuring reliable functioning under low temperatures, also providing an apparatus which is simple to manufacture and to operate, ensuring easy adjustment according to different or variable conditions.

Apparatus for biological cleaning of waste water according to the present invention comprises a first vessel having a denitrification space connected to a crude water intake, a separation space above the denitrification space for fluid filtration provided with an outlet and separated from the denitrification space by means

of an inclined partition wall, the separation space being connected with the denitrification space by means of a sludge outlet, the denitrification space being connected with an activation space formed in a second vessel which is provided with aerating elements and an outlet, the outlet of the second vessel being connected to the separation space.

In a preferred embodiment of the present invention the first vessel is located within the second vessel.

According to another embodiment of the invention the sludge outlet is formed by a tube which extends downwardly from the lower edge of the inclined partition wall.

Another preferred feature is that the sludge outlet extends downwardly to the lower part of the denitrification space or that it terminates with a discharge opening arranged to feed the sludge tangentially into a distributing space formed at the bottom of the denitrification space preferably the distributing space being defined at least partly by a downwardly extending conical wall extending from the sludge outlet and an upwardly extending conical wall of the first vessel and that the separation space comprises an intake for the activating mixture arranged as a vertical tube, preferably coaxial with the axis of the vessel.

A further preferred feature is that the intake for the activating mixture forms the intake of crude water the discharge end of which extends into the sludge outlet.

Embodiments of the invention will now be described by way of example with reference to the accompanying diagrammatic drawings in which:

Figure 1 is a vertical axial section of a first embodiment according to the invention in which two independent treating tanks are provided one beside the other,

Figure 2 is a vertical section of a second embodiment according to the invention, also with two treating tanks beside each other,

Figure 3 is a vertical axial section through a third embodiment of the invention with a coaxial arrangement of the treating tanks,

Figure 4 is a vertical axial section through a fourth embodiment of the invention, and

Figure 5 is a vertical axial section through a fifth embodiment of the invention.

In the embodiment according to Fig. 1 the anaerobic denitrification space 6 is in a tank 1 with a vertical cylindrical mantle. The aerobic activation space 5, in this particular case is in a separate tank 111 with a vertical cylindrical mantle alongside tank 1. Tank 111 has a vertical cover 44 and a bottom 100 the free liquid level of tank 111 being at 116. In an upper part of tank or vessel 1 is an inclined partition wall 2. The wall 2 in this embodiment narrows downwardly conically, and divides tank 1 to form in its upper part a separation space 3 for liquid filtration which is provided at the bottom of space 3 with a sludge outlet 13 for the removal of separated sludge from its lower part. Under the outlet 13 is a baffle plate 46 which overlaps the perpendicular projection of the mouth of the sludge outlet 13.

The anaerobic denitrification space 6 has a sloping conical bottom 40 narrowing downwards and is provided with an outlet 101 and an activating mixture duct 113 that is connected to a pump 20 serving as the circulation means in a closed circulation circuit for the activating mixture between the anaerobic denitrification space 6 and the anaerobic activation space 5.

The delivery duct 23 of the pump 20 terminates at a nozzle 24, which opens into the anti-scum space 25 formed by the cylindrical mantle of tank 111 above the free level 116 in the aerobic activation space 5. The activation space 5 is provided with an outlet 102 in the bottom 100 and with a pneumatic aeration system comprising a known air blower (not shown), an air distributor 60 and aeration elements 28.

At the free level 116 of the aerobic activation space 5 an overflow control 54 of a known type is arranged from which an activated mixture duct 115 leads separately to an intake 8, and thus also to the separation space 3. A regulating by-pass 114 is also provided which opens tangentially, under the inclined partition wall 2, into the denitrification space 6. An outlet 56 for excess activated sludge leads out of the apparatus.

The intake 8 into the separation space 3 is formed as a pipe which terminates above the lowest part of space 3, the lower edge 11 of intake 8 and the partition wall 2 defining an annular inlet 12 into the separation space 3. Above the inlet 12 a degasification cone 9 is mounted on the intake 8 and the cone 9 is provided with degasifying holes 10. At level 30 of the liquid in the separation space 3 is a collecting trough 29 provided with an outlet 31 for cleaned water. The top part of the denitrification space 6 is provided with degasifying tubes 34.

The described apparatus operates in the following way: Crude water that is water or liquid to be treated is delivered through an intake 17 for crude water past the overflow control 54 into the denitrification space 6 through the regulating by-pass 114.

The activation mixture circulates in a substantially closed circulation circuit comprising the anaerobic denitrification space 6 and the aerobic activation space 5. During this process oxidation of ammonia contained in the waste water takes place, as well as the reduction of nitrates and nitrites to gaseous nitrogen through the enzymatic action of micro-organisms in the activated sludge and, consequently, nitrogenous matter is removed from the water or liquid being treated.

The activating mixture duct 115 from the aerobic activation space 5 is connected to the known overflow control 54 which is connected to space 5 by an activation space outlet 119. The duct 115 connected to the separation space 3 via the intake 8, while the activated sludge caught by fluid filtration in the separation space 3 is

automatically returned by gravity to the denitrification space 6 through the sludge outlet 13, and thus into the closed circulation circuit.

Since the effectiveness of denitrification in this embodiment depends on the intensity of circulation in a closed circulation circuit, the intensity of circulation is increased proportionally to the rate of flow of the crude water. This increased circulating amount is delivered outside the intake 8 of the separation space 3 using the regulating by-pass 114, in order to eliminate the disturbing effects of increased streaming intensity in the intake 8 upon the fluid filtration in the separation space 3.

About double the amount of crude water intake into the apparatus appears to be most appropriate for the intake into the separation space, which ensures the best separating operation of the fluid filter. The overflow control 54 acts so as to divide the flow of the activating mixture flowing from the aerobic activation space 5 through the activation space outlet 119, and as well as dividing the activation mixture between the intake 8 into the separation space 3 and the regulating by-pass 114 it also ensures the removal of excessive activation sludge through the outlet 56 for excess activation sludge.

The tangentially terminated regulating by-pass 114 creates a circulating downward stream in the anaerobic denitrification space 6, this stream also comprising some separated activated sludge returning to the separation space 3 through the sludge outlet 13. The orifice or baffle plate 46 prevents gas from the denitrification space 6 from penetrating into the separation space 3 and at the same time it assists in the uniform mixing of the returning activated sludge with the activating mixture in this space.

The activation mixture is taken from the lower narrowing down part of the activation space 6 through activation mixture duct 113. The recirculation of the activation mixture in the embodiment is used also for combatting the scum that is produced on the waste water. This scum has a high concentration of surface active matter when aerated by the pneumatic aeration system. The scum is attacked by spraying the scum in the anti-scum space 25 provided above the liquid level 116. The necessary pressure for spraying the scum is obtained by using the pump 20 which pumps the liquid through the spray nozzle 24.

The purified water that had been cleaned from both nitrogenous and carbonate matter is removed after the separation of activated sludge in the fluid filter by the collecting trough 29 at the level 30 and is discharged from the apparatus through the outlet 21. The gasses released during the denitrification process, particularly gaseous nitrogen, are removed from the denitrification space 6 through degasifying tubes 34, the gasses released at the lower edge 11 of the intake 8 are collected in the degasification cone 9 and removed by the degasifying holes 10 adjacent the intake 8 and thence to the ambient free atmosphere. Drainage of the denitrification space 6 is carried out through the outlet 101 and the drainage of the activation space 5 is through the outlet 102. The activation space 5 is aerated pneumatically through the known aeration elements 28 connected by means of the air distributor 60 to a source of air pressure (not shown).

The described apparatus is designed for the purification of highly polluted waste water with considerable contents of carbonate and nitrogenous and surface active matter, such as liquid slurry from farm animals.

A further embodiment according to the invention is shown in Fig. 2.

The apparatus shown in Fig. 2 consists of two vessels or tanks 1 and 111 located alongside each other each having a vertical cylindrical mantle. The upper part of the tank 1 has a separation space 3 for fluid filtration. Space 3 has an outlet 31 and is divided from the denitrification space 6 by an inclined downwardly narrowing conical partition wall 2. Activating mixture intake 8 for the separation space 3 is provided by an annular space between a low outer part of the inclined partition wall 2 and an opposite separation wall 121 the upper part of which has holes 19. The lower edge of the separation wall 121 extends downward to a sludge outlet 33 which extends into the lower part of the denitrification space 6.

The denitrification space 6 is connected with the activation space 5 formed in the adjacent tank 111. The connection is by means of an activating mixture duct 113 in which is a pump 20, suitably a mammoth type pump arranged directly in the activation space 5. The activation space 5 is provided with aeration elements 28 connected to a not represented source of air pressure. Tank 111 has an outlet 119 connected to an overflow control 54 having three overflows of which the first is connected to the intake 8 of the separation space 3, the second to a regulating by-pass 114 terminating in the denitrification space 6, and the third to an outlet 56 for excess activated sludge. The by-pass 114 is connected also to an intake 17 for crude or untreated water. This embodiment is also particularly suited for treating very highly polluted waste water such as, e.g. liquid waste or slurry from farm animals.

The second embodiment operates as follows:

The cleaning of carbonate matter with simultaneous oxidation of ammonia takes place in the activation space 5. Here, under the presence of oxygen delivered into the activation mixture by the aeration elements 28, the micro-organisms of the activated sludge break away the organic carbonate pollutants of the waste liquid, while oxidizing ammonia into nitrates.

The activated mixture is delivered through the outlet 119 from the activation space 5 to the overflow control 54 where the flow of activation mixture is divided into three parts, namely into the activating mixture duct 115 leading into the intake 8 in the separation space 3, further to the recirculating by-pass 114, and lastly to the outlet 56 for excess activating sludge. The activating

mixture enters the separation space 3 through the intake 8 in which space the cleaned water is separated from the activated sludge by filtration in the fluid layer of activated sludge by upward streaming. The cleaned liquid is collected by collecting trough 29 and drained out of the apparatus through the outlet 31.

The trapped particles of activated sludge coagulate with each other and fall by gravitation to the lower part of the separation space 3, and are delivered through the sludge outlet 13 to the bottom part of the denitrification space 6. The activation mixture from the activation space 5 is circulated to the upper section of space 6 through the recirculating by-pass 114 together with crude water or untreated liquid delivered through the intake 17 to the overflow control 54. The conditions of the dentrification space 6 are anaerobic and, consequently, the denitrification bacteria which are present in the activation sludge affect the nitrates produced in the activation space 5 so that they reduce them into gaseous nitrogen escaping into the free atmosphere through the degasifying outlet 57. The activation mixture is then delivered from the bottom part of the denitrification space 6 into the activation space 5.

A third embodiment in which tanks 1 and 111 are coaxial is shown in Fig. 3.

In such embodiment tank 111 with a cylindrical mantle has an annular aerobic activation space 5 with a free liquid level 116 and this surrounds vessel or tank 1 with a vertical cylindrical mantle having anaerobic denitrification space 6 and separation space 3. Besides this coaxial arrangement of both vessels the embodiment of Fig. 4 has variations in the connection between the tanks and the anaerobic denitrification space.

The outlet 119 of the activation space in this embodiment is connected to the discharge of pump 21, suitably of the mammoth type, with an air intake 52 arranged in the activation space 5 which also houses the pneumatic aeration system comprising the air distributor 60 and the aeration elements 28.

The outlet 119, is connected to the overflow control 54 where the flow of activation mixture is divided into three streams. One of the streams is delivered through the activation mixture duct 115 to the intake 8 and from here through the annular inlet 12 formed between the lower edge 11 of the intake 8 and the opposite part of the inclined partition wall 2, whence it flow into the separation space 3. The second stream is fed through the regulating by-pass 114 connected to the crude water intake 17 into the sludge outlet 13, and thus into the bottom part of the denitrification space 6.

The outlet 56 for excess activation sludge serves to discharge the third stream from the overflow control 54.

The bottom part of the sludge outlet 13 has a downwardly opening funnel 14 mounted to it which together with an opposite part of downwardly narrowing bottom 40, defines a distributing space 15 into which the sludge outlet 13 opens with a tangential discharge opening 18. The distributing space 15 is connected with the denitrification space 6 by means of a passage 16. The outlet of the activation mixture from the anaerobic denitrification space 6 is formed by the passages 49 in the upper part of the wall or mantle of tank 1 through which communication is provided with the adjoining aerobic activation space 5; accordingly, the direction of the activation mixture flow in the denitrification space 6 is upwards.

The separation space 3 is provided with a degasification cone 9. The deaeration of the degasification cone 9 is by means of degasifying holes 10 around the inlet 8 to the separation space 3. At the liquid level 30 in the separation space 3 there is provided a collecting trough 29 with outlet 31. Tank 1 is provided with a cover 26 which covers the separation space 3. The cylindrical mantle of tank 111 above the free liquid level 116 in the activation space 5 and above the cover 26 defines the anti-scum space 25 with a scum level 118 where mechanical scum breakers 117 are located. The denitrification space 6 is provided with an outlet 101 and the activation space 5 with an outlet 102.

The apparatus illustrated in Fig. 3 works in a similar way to the apparatus of Fig. 1. Crude water or untreated liquid is delivered from the intake 17 into the regulating by-pass 114 which leads to the sludge outlet 13 serving for the simultaneous return of activated sludge separated by fluid filtration in the separation space 3, back to the activation cleaning process. The sludge outlet 13 opens into the distribution space 15 where its tangential discharge 18 causes the suspension to rotate in a desirable way. Through the passage 16 the activation mixture enters the denitrification space 6, flows upwards, and enters the activation space 5 through the passages 49 in the vertical cylindrical wall or mantle of tank 1.

The size of cross-section of the passage 16 is 2 to 2.5% of the cylindrical cross section of the denitrification space 6, which ensures most favourable conditions for a perfect fluidization of the activated sludge and, consequently also for the denitrification processes.

The circulation between the denitrification space 6 and the activation space 5 is ensured by the mammoth pump 21 pumping the activation mixture to the overflow control 54 which acts so as to divide the activating mixture into three parts, namely, as has been previously mentioned, into a first part or stream fed to the separation space 3 wherefrom, after the separation of activated sludge by fluid filtration, the purified water is removed through the collecting trough 29 and further by the outlet 31; a second part passes through the control bypass 114 and a third part, being the excess activated sludge, is evacuated by the outlet 56 outside the cleaning apparatus.

Unlike the first embodiment, the third

embodiment does not use the circulating activation mixture for breaking up the scum by spraying. The mechanical scum breakers 117 serve for this purpose, and their effect, as well as the force of gravity acting upon the scum, maintained the scum surface 118 at the required level.

The apparatus according to Fig. 3 is designed for cleaning waste water or slurry with high contents of carbonate, nitrogenous and surface active matter; its coaxial construction, however, makes it particularly well adapted for cooler climates and for such applications where mechanical scum breakers without the necessity of spraying are sufficient.

A fourth embodiment is illustrated in Fig. 4 in which tanks 1 and 111 are again coaxial. Tank 111 having activation space 5 surrounds tank 1 denitrification space 6 and separation space 3. The separation space 3 extends outwards to the outer wall of tank 111, the inclined partition wall 2 over the denitrification space 6 also covering activation space 5. Again, as a circulation means a pump 21 is used, suitably of the mammoth type, having an air intake 52 at the discharge of which, forming the outlet 119, the control overflow 54 is arranged wherefrom the activation mixture duct 115 from the aerobic activation space 5 is leading which enters the intake 8, and thus also the separation space 3.

The control overflow 54 is further connected to the outlet 56 of excess activation sludge. The inlet 12 into the separation space 3 is formed by the lower edge 11 of the intake 8 and the opposite part of the inclined partition wall 2 limiting the separation space 3 from the bottom. The separation space 3 houses the degasification cone 9 connected with the degasifying holes 10 and with the intake 8. At the level 30 of the liquid the collecting trough 29 is provided with the outlet pipe 31. The bottom part of the tapered separation space 3 is connected through the sludge outlet 13 of separated activated sludge with the anaerobic denitrification space 6. The intake 17 of crude water enters the sludge outlet 13 and under the mouth of the sludge outlet 13 an orifice plate 46 is arranged so as to cover the vertical projection of the mouth of the outlet 13.

The outlet of the activation mixture from the anaerobic denitrification space 6 is formed, at the one hand, by passages 50 in the tank 1 arranged in the tank wall adjacent the bottom 40 and, on the other hand, by passages 49 in the tank wall in the upper part of the denitrification space 6, while the flow of the activation mixture through the anaerobic denitrification space 6 is oriented downwards in the region under the mouth of the sludge outlet 13 of separated sludge, and upwards in the region above the said mouth.

The aerobic activation space 5 communicates with the free atmosphere by means of the de-aeration outlet 57. The outlet 102 serves for draining the whole apparatus.

An apparatus according to Fig. 4 operates with following differences as compared with the previous embodiments. No recirculating bypass 114 is used. The pump 21, i.e. the source of the circulation of liquid, pumps only the amount required for delivering into the separation space 3, which is double the overall intake to the apparatus at the minimum, and is sufficient for the removal of the separated activated sludge. In such case the intensity of circulation equals one. This would not do for maintaining the activated sludge in the anaerobic denitrification space 6 under conditions of perfect fluidization and, for this reason, the streaming in this space has been designed in downward direction as in the embodiment according to Fig. 1. Since, however, this embodiment has no recirculating bypass 114 that is arranged in the upper part of the aerobic activation space 5 in the embodiment according to Fig. 1, the section of the anaerobic denitrification space 6 above the sludge outlet 13 would remain unused, and therefore the activating mixture duct 113 from the anaerobic denitrification space 6 is designed both at the bottom, by lower passages 50, and at the top, by the passages 49. Both passages have the form of holes in the mantle 1 and their different flow sections divide the flow upwards and downwards so as to correspond to the volumes of the anaerobic denitrification space 6 above and under the sludge outlet 13. The separation space 3 extends right over tank 111 and the removal of gas brought in by the aeration system is ensured by the de-aeration outlet 57.

Such apparatus is appropriate for cleaning waste water polluted with lower concentrations of carbonate and nitrogenous matter with small amounts of surface active matter, having no tendency to foaming, such as, e.g., waste water from industrial meat plants etc.

In an embodiment according to Fig. 5 the vessel comprising the denitrification space 6 above which the separation space 3 is situated, and the vessel comprising the activation space 5 are arranged so as to allow the vessel with denitrification space 6 to be within the vessel with the activation space 5. The arrangement of both vessels is preferably coaxial, while the inclined partition wall 2, separating the separation space 3, overlaps the denitrification space 6 and covers also the activation space 5.

The intake 8 of the activation mixture into the activation space 5 is formed by the space between the lower outer part of the inclined partition wall 2 and the opposite separation wall 121 in the top part of which the holes 115 are arranged. The lower edge of the separation wall 121 is followed by the sludge outlet 13. The connection of the denitrification space 6 with the activation space 5 is ensured through the activating mixture duct 113 leading under the tapered bottom 90 with holes 123. The activating mixture duct 113 is terminated by the mammoth pump 122 in the activation space 5. The upper part of the denitrification space 6 is connected with the activation space 5 through the recirculating bypass 114 receiving the intake 17

of crude water. The top of the denitrification space 6 in the tank 1 is provided with degasifying holes 120.

The activation space 5 is provided with aeration elements 28 connected over the air distributor 60 with a not represented source of pressure air. The top part of the activation space 5 closed from the top by the partition wall 2, houses the de-aeration 57. The separation space 3 accommodates the degasification cone 9 and the collecting trough 29 from which the outlet 31 of cleaned water leads out of the apparatus.

The described apparatus operates as follows:

The crude water is brought through the intake 17 to the recirculating bypass 114 connecting the activation space 5 with the denitrification space 6. The recirculation bypass mouths in the top part of the denitrification space 6 in the direction of the normal, which makes the entering recirculated activation mixture to perform a rotary movement within the denitrification space 6. The activation mixture entering the denitrification space 6 contains nitrates produced in the process of the aerobic activation cleaning in the activation space 5 along with the biodegradation of organic matter.

Under the presence of organic matter in the incoming crude waste water as hydrogen donators, the reduction of nitrates to gaseous nitrogen takes place in the denitrification space 6, this process developing during the spiral downward movement of the activation mixture within the denitrification space 6. The thus produced gaseous nitrogen passes through the degasifying holes 120 to the activation space 5 and therefrom by de-aeration 57 into the free atmosphere.

The withdrawal of the activation mixture from the denitrification space 6 is carried out in its bottom part by means of the duct 113 leading to the activation space 5. As a pump the mammoth pump 122 is used. In order to ensure regular withdrawal of the activation mixture from the activation space 5 and to prevent any dead corners a tapered bottom 40 is provided with holes 123 under which the duct 113 is mouthing.

In the activation space 5 under the pressure of diluted oxygen delivered by the aeration system the aerobic activating biodegradation of carbonate organic matter takes place along with a forced oxidation of ammonia to nitrates which, as has been described above, are reduced to gaseous nitrogen by denitrification processes in the denitrification space 6.

The effectivity of removing the nitrates depends from the intensity of circulation of the activation mixture between the activation and denitrification spaces. The described by-pass 114 and the activation mixture duct 113 are provided for achieving the desired circulation which can be adjusted by way of controlling the amount of air delivered to the mammoth pump 122. For lower pollution degress of waste water by nitrogenous matter an intensity of circulation between the activation space 5 and the denitrification space 6 of double to nine times the intake to the cleaning plant is sufficient. In case of water with higher concentrations of nitrogenous matter, an effective elimination of nitrates can be achieved with circulation amounting to tens of times of the inflow. For the withdrawal of activated sludge from the cleaned water the filtration in a fluid filter in the separation space 3 is applied. The activation mixture comes to the separation space 3 through holes having the function of an activation mixture duct 115, and through the mentioned intake 8. Turning around the lower edge of the inclined partition wall 2, the stream of activated mixture ascends and enters the fluid filter where the separation of particles of activated sludge from the cleaned water takes place by way of filtration. The particles of air that are excluded at the lower edge of the partition wall 2, at the turning point of the stream of the activating mixture, are caught by the degasification cone 9 and the purified water cleaned from the activated sludge is withdrawn by the collecting trough 29 and discharged outside the apparatus over the outlet 31.

The particles of activated sludge that have been caught by filtration and coagulated fall under the effect of gravitation to the bottom part of the separation space 3 and proceed further by the sludge removal 13 into the denitrification space 6. The high effectivity of separation of the activated sludge by fluid filtration results in high concentration of activated sludge in the cleaning process, and thus also in the necessary age of sludge, which is of particular importance for the course of the nitrification and denitrification processes brought about by nitrification and denitrification micro-organisms having considerably lower growing velocities than the micro-organisms causing the biodegradation of carbonate organic matter. For this reason, in order to achieve the breed of the specific nitrification and denitrification microorganisms, a sufficient age of the sludge should be ensured. The embodiment illustrated in Fig. 5 is particularly adapted for less concentrated waste water with lower contents of carbonate pollution.

The apparatus according to the present invention have various advantages. As compared with known apparatus in which the separation of activated sludge is by sedimentation and the separated activated sludge is by sedimentation and the separated activated sludge is subject to forced return in the apparatus according to the present invention remarkable improvements of technological character can be achieved. A markedly higher concentration of the activated sludge is obtained as compared with reactors with the separation of the suspension by sedimentation due to the fact that the surface load of the fluid filter by solid matter is 2 to 3 times higher than in the case of sedimentation. Achieving a higher concentration of activated sludge in the ratio of effectivity of both separation processes is particularly important for the nitrification and denitrification processes, since

the intensity of the process depends from the amount of nitrification and denitrification micro-organisms with the biocenosis of the activated sludge. Since cultures breaking away the nitrates can only breed at a slower rate than the cultures of microorganisms biodegrading carbonate organic matter, the relative representation of nitrification and denitrification micro-organisms depends on the age of the sludge, which in turn depends on the concentration of sludge in the process. Consequently, the usage of fluid filtration for removing nitrogenous matter from water brings a substantial intensification of the purification process.

As compared with known reactors using fluid filtration for cleaning water from carbonates along with nitrates where the separated activated sludge is returned to the aerobic activating space, apparatus according to the present invention achieves a higher concentration of activated sludge by way of its returning directly to the anaerobic denitrification space.

Another advantage of an arrangement of an apparatus according to the present invention resides in the possibility of providing a large anti-scum space above the free level in the aerobic activation space, with the possibility of breaking the scum by spraying or mechanically—by gravitation. This appears to be particularly important for waste water with a pronounced foaming tendency in case of high contents of surface active matter, such as, e.g., the waste water from animal farms. This fact brings further advantages of technological character, since the effective scum breaking according to the present invention allows pneumatic aeration systems to be used. A pneumatic system, as compared with mechanical surface aeration systems, does not contribute to the loosening of the produced scum, even rather supports it, yet its great advantage resides in that it does not cool down the activation mixture, as the mechanical aeration systems do. This contributes decisively to maintaining the best conditions for the course of the nitrification and denitrification processes where the temperature of the activation mixture should not drop under 13 °C; below this limit the purification processes are slowed down considerably, which makes it necessary to warm up the activation mixture during the winter months, if the temperature drops to this margin. In an apparatus according to the present invention, particularly in an embodiment as illustrated in Fig. 2, the achievable temperature balance is such that there is no need to add any heat to the system, not even during frost periods of −30°C, thus creating prerequisites for excellent economy, e.g. an economy of up to 100,000 kcalQ^{-1} for a cleaning plant for 15,000 pigs. Further advantages are the high effectivity of eliminating nitrogenous matter, adjustable by controlling the degree of the circulating by-pass.

Apart from these favourable features from the viewpoint of technology, the apparatus according to the present invention has also considerable advantages from the viewpoint of design. In general terms, the design is simple from the production criteria, very adaptable for various capacities, and also for variable pollution both as to carbonate and nitrogenous matter contents, as well as surface active pollutants. In this way, while maintaining the essential features, the apparatus can be adjusted to the type of waste water encountered by partially modifying the hydraulic arrangement and changing the volumes of various operation rooms. Thus very broad varieties of water cleaning requirements can be covered, from sewage water to concentrated waste from animal farms.

The vertical design of tanks is favourable both for the aerobic activation from the viewpoint of the applied pneumatic aeration system, and for the anaerobic denitrification, since it allows such streaming in the denitrification space which does not require any mechanical mixing, as is the case in current known systems. The connection of the separation space with the anaerobic denitrification space where the intense circulating stream is not brought about by aeration offers a substantial simplification of the hydraulic system of separation against the common known systems where the returning separated activation mixture is brought to the aerobic activation space.

When using the coaxial tank construction the mentioned advantages are increased by the simplicity of connections and the minimum external surface of the mantle, which adds to the favourable temperature balance of the system. The cylindrical shape of the enclosing walls or mantles makes production and assembly very easy.

The simplicity of the apparatus according to the present invention and its broad flexibility for various types of waste water along with the achieved high intensity of cleaning processes resulting in small dimensions of the apparatus and high cleaning effectivity make the apparatus according to this invention a new type of equipment characterized by high parameters of operation, allowing to cope with the ever increasing requirements for the quality of purified water on a broad scale with good economy. Thus, it opens a new generation of crude water or slurry cleaning plant.

Claims

1. Apparatus for biological cleaning of waste water containing carbonates and nitrates by means of anaerobic denitrification, aerobic activation and nitrification by means of uniform activated sludge, comprising a first vessel having a denitrification space connected to a crude water intake, a separation space above the denitrification space for fluid filtration provided with an outlet and separated from the denitrification space by means of an inclined partition wall, the separation space being connected with the denitrification space by means of a sludge outlet, the denitrification space being connected with an activation spaced

formed in a second vessel which is provided with aerating elements and an outlet, the outlet of the second vessel being connected to the separation space.

2. Apparatus as claimed in Claim 1 wherein the first vessel has a cylindrical vertical mantle and the partition wall is conical.

3. Apparatus as claimed in Claim 1 or 2 wherein the second vessel has a cylindrical mantle.

4. Apparatus according to any one of Claims 1 to 3 wherein the first vessel is located within the second vessel.

5. Apparatus according to any one of Claims 1 to 4 wherein the first and second vessels are coaxial and the inclined partition wall extends over the denitrification space to cover the activation space.

6. Apparatus according to any one of Claims 1 to 5 wherein the sludge outlet is formed by a tube which extends downwardly from the lower edge of the inclined partition wall.

7. Apparatus according to any one of Claims 1 to 6 wherein a baffle plate is provided adjacent the discharge side of the sludge outlet.

8. Apparatus according to any one of Claims 1 to 7 wherein the sludge outlet extends downwardly to the lower part of the denitrification space.

9. Apparatus according to any one of Claims 1 to 8 wherein the sludge outlet is provided with a discharge opening arranged to feed the sludge tangentially into a distributing space formed at the bottom of the denitrification space.

10. Apparatus according to Claim 9 wherein the distributing space is defined at least partly by a downwardly extending conical wall extending from the sludge outlet and an upwardly extending conical wall of the first vessel.

11. Apparatus according to any one of Claims 1 to 10 wherein the separation space comprises an intake for the activating mixture arranged as a vertical tube, the lower edge of which extends into the lower part of the separation space and which intake is connected to the outlet of the activating space by means of an activating mixture duct and an overflow control.

12. Apparatus according to Claim 11 wherein the activating mixture intake tube is coaxial with the first vessel.

13. Apparatus according to claim 11 or 12 wherein the activating mixture intake forms the intake of crude water the discharge end of which extends into the sludge outlet.

14. Apparatus according to any one of claims 1 to 10 wherein an intake for the activating mixture is formed by a space between a lower outlet part of the inclined partition wall and an opposite separation wall the upper part of which is provided with holes forming an outlet for the activating mixture, the lower edge of the separation wall being extended to form the sludge outlet.

15. Apparatus according to any one of claims 1 to 14 wherein a pump is provided to pump liquid from the denitrification space into the activation space the delivery of the pump, preferably being above the free level of the liquid in the activating space.

16. Apparatus according to any one of claims 1 to 14 wherein the denitrification space communicates with the activation space by means of passages formed in an upper part of the first vessel.

17. Apparatus according to claim 16 wherein the denitrification space also communicates with the activation space by means of passages formed in a lower part of the first vessel.

18. Apparatus according to any one of claims 1 to 14 wherein the denitrification space communicates with the activation space by means of the outlet extending under a tapered bottom with holes, the outlet of the mixture in the activating space terminating by a mammoth pump.

19. Apparatus according to any one of claims 1 to 18 wherein the activating space is connected to the denitrification space by means of a controllable by-pass.

20. Apparatus according to claim 18 wherein the by-pass connection is either by means of a controllable overflow or by a part of an activating mixture duct and the sludge outlet.

21. Apparatus for biological cleaning of waste water substantially as described with reference to figure 1 of the accompanying drawings.

22. Apparatus for biological cleaning of waste water substantially as described with reference to figure 2 of the accompanying drawings.

23. Apparatus for biological cleaning of waste water substantially as described with reference to figure 3 of the accompanying drawings.

24. Apparatus for biological cleaning of waste water substantially as described with reference to figure 4 of the accompanying drawings.

25. Apparatus for biological cleaning of waste water substantially as described with reference to figure 5 of the accompanying drawings.

Printed for Her Majesty's Stationery Office by the Courier Press, Leamington Spa, 1983. Published by the Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained